ECRONICON OPEN ACCESS

EC DENTAL SCIENCE
Review Article

Synopsis is Using Dental Diode Laser in Endodontic-Part 2

Dr. Ayman El-Zohairy[1]* and Rasha Fouad Serageldin[2]

[1]*MSc. in laser in dentistry, Aachen University, Germany*
[2]*Department of periodontology, Cairo University, Egypt*

***Corresponding Author**: Dr. Ayman El-Zohairy, MSc. in laser in dentistry, Aachen University, Germany.

Received: November 18, 2016; **Published:** November 29, 2016

Abstract

The success of endodontic treatment therapy depends on how well we eliminate pathogenic microflora from the root canal system as microorganism as the major cause of root canal infection. Conventional root canal treatment can fail if microorganisms cannot be removed sufficiently by thorough cleaning, shaping of root canal. Newer modalities such as photodynamic therapy are being tried now a days for disinfection of root canals.

The complexity of the anatomy of the root renders the access to the germs in periapical and inside dentinal tubules difficult. As a result, complete removal of bacterial germs with the mechanical method alone is impossible, and adjunctive treatments have been recommended to facilitate bacterial germs elimination [1,2]. One of the adjunctive treatments is the administration of antibiotics. It has been demonstrated that antibiotics either systemic or local are effective in the reduction of root canal pathogens [3,4]. The use of antibiotics has two basic problems; the first one is maintenance of the drug therapeutic concentration in the periapical region and accessory canals for enough time to be certain of microorganism's elimination, since a collection of gram positive and gram negative bacteria in a polymeric matrix on the dental surface is an obstacle for the antimicrobial drug activity [5]. Consequently, inappropriate drug concentration in periapical region, accessory canals and biofilms results in an insufficient antimicrobial effect. The second problem is the appearance of drug resistant strains of bacteria and changes in bacterial normal flora as a consequence of wide use of antibiotics [6,7].

In upcoming years, problems rising from treatments with antibiotics will increase for the following reasons:

1- Increased resistance to antibiotics
2- Increase of immunosuppressed patients [8]
3- endodontic infections with various bacteria different from local pathogens, and the consequent need for different and multiple antibiotics [9] Due to these factors, the efforts toward adjunctive treatment modalities continue.

Photodynamic therapy (PDT) is presented as a promising antimicrobial therapy that can eliminate microorganisms present in endodontic infections.

Keywords: *Diode Laser; Root Canal; Endodontic; Photodynamic Therapy*

Antimicrobial Photodynamic Therapy

aPDT or Photoradiation therapy, phototherapy, or photochemical therapy was first introduced by Raab in 1990 [10]. Allison., *et al*. named aPDT as a treatment composed of light and drug [11].
aPDT has three component:

1- Light

2- A substance sensitive to light (Photosensitizer)

3- Free radical and singlet oxygen [12]

Photosensitizing agent (Ps)

In order to generate the desired effect of the PDT, the PS must have selectivity and biological stability, good photochemical action and low toxicity to healthy tissues [13,14]. The PS must have a resonant absorption band with spectrum of action of light on a particular wavelength of maximum absorption. The effect of PDT in the tissue depends on the level of PS [15-17]. The closer the wavelength of light used in the PS, the more efficient the PDT, provided that this PS has low toxicity and absorption bands that do not cause any injury to adjacent tissues and biological target [10]. The action of PS on bacteria is directly related to the load. PS with positive or neutral charge interacts in a dynamic way, inactivating the layer of peptidoglycan and lipoteichoic acid in the outer membrane of Gram-positive and allows PS diffusion [18,19]. In Gram-negative bacteria, PS interacts with their outer membrane, acting as a functional and physical barrier among the cells and the biological environment [20,21].

The PS most commonly reported in the literatures are: methylene blue, toluidine blue, rose bengal, malachite green, erythrosine, rhodamine, porphyrins, and phthalocyanines.

In Endodontics, it is possible to employ the PDT with PS of the phenothiazine class: methylene blue (MB) and toluidine blue (TB), both activated by red laser or LED.

Photosensitizers

Chemically, many photosensitizers belong to dyes and porphyrin-chlorine groups. A variety of photosensitizers include:

1. Dyes: Tricyclic dyes with different meso-atoms - methylene blue, toluidine blue O and acridine orange; and phthalocyanines - aluminum disulfonated phthalocyanine and cationic Zn (II) - phthalocyanine.

2. Chlorines: Chlorine e6, stannous (IV) chlorine e6, chlorine e6-2.5 N-methyl-d-glucamine, polylysine and polyethyleneimine conjugates of chlorine e6.

3. Porphyrins: Hematoporphyrin HCl, photofrin and 5 aminolevulinic acid (ALA), benzoporphyrin derivative.

4. Xanthenes: Erythrosine.

5. Monoterpene: Azulene.

Photosensitizers can also be activated by low power visible light at a specific wavelength. Activation of the photosensitizer is dependent on the total light dose, the dose rates, the depth of light penetration and the localization of target area.

Optimal Properties of a Photosensitizer

1-Highly selective.
2-Low toxicity and fast elimination from skin and epithelium.
3-High quantum yield of singlet oxygen production *in vivo*.
4-High solubility in water, injection solutions and blood substitutes.
5-Storage and application light stability.

Light used in photodynamic therapy

1-Laser presents peculiar characteristics such as: monochromaticity, little divergence, intense energy and ultra-short pulses.
2-LED is an acronym for Light Emitting Diode, a low thermal component with a spontaneous radiation mechanism that requires little energy to generate light. Photodynamic therapy is among the applications of laser and LED for therapeutic purposes.

Low intensity red lasers are extensively used in PDT because they absorb phenothiazine-based PS and are absorbed by biological tissues.

LED has been used in optical techniques as an alternative to the use of laser because it provides spontaneous radiation and uses little energy to generate light, with results as good as those of laser.

Photodynamic therapy (PDT)

Uses photoactive dye (photosensitizer) which in the presence of oxygen gets activated on exposure to light of a specific wave length. The energy which is transferred from the activated photosensitizer to available oxygen results in to the formation singlet oxygen and free radicals which are toxic oxygen species. These highly reactive chemical species can damage proteins, lipids, nucleic acids, and other cellular components. The most important property of PDT is that the bacteria present in root canal system do not develop resistance to PDT. It is effective on viruses, fungus and protozoa, kills bacteria rapidly and works instantaneously.

The singlet oxygen and free radicals are produced which lead to tissue damage. As a result, aPDT is perfect for local application without damage to cells further away

Advantages of the use of aPDT in endodontic treatments

1- Bacterial resistance to aPDT is less probable, since the singlet oxygen and the free radicals interact with different cells structures and in different metabolic ways.
2- aPDT is a local non-invasive modality and does not damage the tissues surrounding the target location and even the micro flora around.
3- aPDT eliminates the non-accessible pathogens in the infected root canal in a short time, it is then beneficial to the clinician and the patient.
4- The risk of bacteremia after endodontic treatment with aPDT is the least.
5- There is no need for antibiotic prescription.
6- There is no need for local application of anesthetics, and damage to the bacteria occurs in a shorter time (less than 60s).

J. Arentz Hamburg, Germany in his lecture addresses a new approach to antimicrobial photodynamic therapy based on phenothiazine derivates combined with an 810-nm coherent light source. It is shown that there is a possibility to obtain a higher output of singlet oxygen and reactive oxygen species in combination with a depot bactericidal effect and a deeper penetration into the tissue to reduce treatment time in comparison to conventional aPDT systems, for example, for full mouth disinfection and to increase wound healing effects. Case reports are shown of periodontitis, periimplantitis, endodontical problems and treatments in veterinary medicine.

Lui., *et al.* 342011, China, Split-mouth, RCTChP uses Methylene blue Diode laser (Ezlase,BIOLASE Tech.,USA) Wavelength 940 nm , Energy 1 W Application tie 30 s/tooth Energy density 4 J/cm2 Fiber tip diameter 300 mm Significant reduction of micro-organism in gingival pockets.

Srikanth., *et al*. 37 2015, India,Split-mouth,RCT, they used Indocyanine green (Aurogreen Aurolabs,Madurai, Tamil Nadu, India) Diode laser (firm not specified) with application of Wavelength 810 nm Power output 0.7 W Application time 5 s/site,they found signeficat decrease of viable micro-organisms.

Table 2. Photodynamic Therapy Parameters Adopted per Study

Reference	PS	PS Concentration	PIT (sec)	LS	λ (nm)	ICF	RD (J or J/cm²)
Seal et al. 2002	TB	12.5, 25, 50, 100 μgmL–1	30	Laser	632.8	No	2.1–21 J
Bonsor et al. 2006[24]	TB	✪	60	Laser	633±2	Yes	12 J
Bonsor et al. 2006[25]	TB	✪	60	Laser	633±2	Yes	12 J
Williams et al. 2006	TB	10.0, 20.0 mg L-1	0/30/60	Laser	633±2	Yes	9.6–15.8 J
Silva Garcez et al. 2006	Azulen-based paste	✪	300	Laser	685	Yes	9 J
Soukos et al. 2006	MB	25 μg/mL	300	Laser	665	Yes	70 J
Gerge and Kishen 2007	MIX	✪	1800	Laser	664	No	36 J
Garcez et al. 2007	PEI+CE6	✪	600	Laser	660	Yes	9.6 J
Foschi et al. 2007	MB	6.25 μg/mL	300	Laser	665±2	Yes	18.96 J
Fimple et al. 2008	MB	25 μg/mL	600	Laser	665	Yes	30 J/cm²
Garcez et al. 2008	PEI+CE6	✪	120	Laser	660	Yes	9.6 J
Bergmans et al. 2008	PEI+CE6	12.7 mg mL-1	60	Laser	635	Yes	15 J
George and Kishen 2008	PF4	✪	600	Laser	664	No	31.84 J/cm²
Fonseca et al. 2008	TB	0.0125%	300	Laser	660	Yes	6.4 J
Lim et al. 2009	MIX	✪	0/1200	Laser	660	No	36 J
Pagonis et al. 2010	MB+PGLA	6.25 μg/mL	900	Laser	665	Yes	30 J/cm²
Souza et al. 2010	MB/TB	15 μg/mL	120	Laser	660	Yes	9.6 J
Upadya and Kishen 2010	MIX/PF4	✪	900	Noncoherent	660	No	2–40 J
Kishen et al. 2010	RB/MB/MB+EPI	100 μM EPI 0.49 mg mL-1	900	Noncoherent	540±15 for RB/660±15 for MB	No	2–30 J/cm²
Garcez et al. 2010	PEI+CE6	✪	120	Laser	660	Yes	9.6 J
Schlafer et al. 2010	TB	100 μg/mL	60	LED	600–660 (628 peak)	Yes	30 J
Rios et al. 2011	TB	✪	30	LED	600–660 (628 peak)	Yes	30 J
Ng et al. 2011	MB	50 μg/mL	300	Laser	665	Yes	30 J/cm²
Nunes et al. 2011	MB	0.01%	300	Laser	660	Yes	8.1–16.2 J
Garcez et al. 2013	MB	60 μM	600	Laser	660	Yes	9.6 J
Cheng et al. 2012	MB	0.01 mg/mL	0	Laser	660	Yes	12 J
Shrestha et al. 2012	CSRB	✪	900	✪	540	✪	5–60 J/cm²
Shrestha and Kishen 2012	CSnps/RB/MB	✪	900	✪	✪	✪	5 and 10 J/cm²
Silva et al. 2012	Phenothiazine chloride	10 mg/mL	60	Laser	660	Yes	3.3 J/cm²
Eldeniz et al. 2013	TB	0.1 mg/mL	60	LED	620–640 (630 peak)	Yes	30 J
Stojicic et al. 2013	MB+	15 μM/L-1	0/300	Laser	660	No	1.2/2.4/7.2 J
Bago et al. 2013	TB/phenothiazine chloride	155μg mL-1/ 10 mg mL-1	60/120	Laser	660	Yes	6 J
Komine and Tsujimoto 2013	MB	0.01%	0	Laser	660	No	53/106/159 J/cm²

PS, photosensitizer; PIT, pre-irradiation time; LS, light source; λ, wavelenght; ICF, intracal fiber; RD, radiation dose;
TB, toluidine blue; MB, methilene blue; MIX, MB in glycerol:ethanol:water (30:20:50); PEI+CE6, polyethylenimine and chlorin-e6 conjugate;
PF4, MB+perfluoro (decahydronaphthalene):H2O2:triton-X100; MB+PGLA, MB-loaded nanoparticles; RB, rose bengal;
MB+EPI, associated with efflux pump inhibitor (EPI), verapamil hydrochloride; CSRB, rose bengal-conjugated chitosan; CSnps, chitosan nanoparticles;
MB+, different associations.
✪ Uninformed.

178

Using the photo-activated chemotherapy in the endodontics (case example)

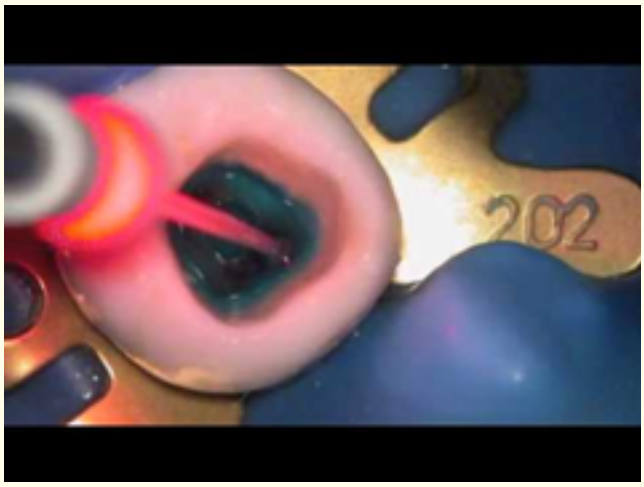
The region that has to be disinfected (root canal) is moistened with the photosensitizer (toluidine chloride, methylene blue) after conventional mechanical-chemical preparation and conditioning.

After a reaction time of 60 sec. the toluidine chloride is brought in into the canal over a light sensor with the specific light source of precisely 635 nm wavelength, approximately 100 nW power and activated for approximately 60 - 150 sec. By this means the toluidine chloride forms active oxygen directly at the bacteria, which destroys the cell walls of the bacteria selectively.

Step 1: After the mechanical-chemical preparation using a preparations gel, alternating rinsing, for example with NaOCl-solution and final rinsing with the root canal conditioner, the canal is dried and filled with toluidine chloride solution (reaction time approx. 1 min). Toluidine chloride in the indicated concentration doesn't cause any blue changes in color.

Step 2: All canals are treated with photo-activated disinfection light for approx. 150 sec., using the detachable endodontics point.

Step 3: The with the photo-activated disinfection treated canals are rinsed with (for example) sterile water, dried and treated with a root canal filling after it.



Bibliography

1. Petersilka GJ., *et al*. "Subgingival plaque removal at interdental sites using a low-abrasive air polishing powder". *Journal of Periodontology* 74.3 (2003): 307-311.

2. Cugini M., *et al*. "The effect of scaling and root planing on the clinical and microbiological parameters of periodontal diseases: 12-month results". *Journal of Clinical Periodontology* 27.1 (2000): 30-36.

3. Drisko CH. "Non-surgical pocket therapy: pharmacotherapeutics". *Annals of Periodontology* 1.1 (1996): 491- 566.

4. Tonetti MS., *et al.* "The use of topical antibiotics in periodontal pockets". *In: Lang NP, Karring T (eds) Proceedings of the 2nd European Workshop on Periodontology, Quintessence* (1997): 78-109.

5. Socransky SS and Haffajee AD. "Dental biofilms: difficult therapeutic targets". *Periodontology* 28 (2002): 12-55.

6. Walker CB. "The acquisition of antibiotic resistance in the periodontal microflora". *Periodontology* 10 (1996): 79-88.

7. Feres M., *et al*. "Antibiotic resistance of subgingival species during and after antibiotic therapy". Journal of *Clinical Periodontology* 29.8 (2002): 724-735.

8. Ryder MI. "An update on HIV and periodontal disease". *Journal of Periodontology* 73.9 (2002): 1071-1078.

9. Muller HP., *et al*. "In vitro antimicrobial susceptibility of oral strains of Actinobacillus actinomycetemcomitans to seven antibiotics". *Journal of Clinical Periodontology* 29.8 (2002): 736-742.

10. Raab O. "[The effect of fluorescent agents on infusoria]". *Journal for Biology* 39 (1900): 524-526.

11. Allison RR., *et al*. "The future of photodynamic therapy in oncology". *Future Oncology* 2.1 (2006): 53-71.

12. Raghavendra M., *et al*. "Photodynamic therapy: a targeted therapy in periodontics". *Australian Dental Journal* 54.1 (2009): S102-S109.

13. Ochsner M. "Photophysical and photobiological processes in the photodynamic therapy of tumours". *Journal of Photochemistry and Photobiology B* 39.1 (1997): 1-18.

14. Wilson BC and Patterson MS. "The physics of photodynamic therapy". *Physics in Medicine and Biology* 31.4 (1986): 327-360.

15. Wilson BC and Patterson MS. "The physics, biophysics and technology of photodynamic therapy". *Physics in Medicine and Biology* 53.9 (2008): R61-R109.

16. Allison RR and Moghissi K. "Photodynamic Therapy (PDT): PDT Mechanisms". *Clinical Endoscopy* 46.1 (2013): 24-29.

17. Wilson M., *et al*. "Sensitization of oral bacteria to killing by low-power laser radiation". *Current Microbiology* 25.2 (1992): 77-81.

18. Foschi F., *et al*. "Detection of bacteria in endodontic samples by polymerase chain reaction assays and association with deined clinical signs in Italian patients". *Oral Microbiology and Immunology* 20.5 (2005): 289-295.

19. Pereira de Lima Carvalho D., *et al*. "Study of photodynamic therapy in the control of isolated microorganisms from infected wounds-an in vitro study". *Lasers in Medical Science* 29.1 (2014): 113-120.

20. Ng R., *et al*. "Endodontic photodynamic therapy ex vivo". *Journal of Endodontics* 37.2 (2011): 217-222.

21. Soukos NS., *et al*. "Photodynamic therapy for endodontic disinfection". *Journal of Endodontics* 32.10 (2006): 979-984.

Volume 6 Issue 2 November 2016